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Analysis and management of pathogens isolated from patients with complicated facial lacerations and abrasions

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Abstract

Plastic surgeons commonly encounter patients with facial lacerations and/or abrasions in the emergency room. If they are properly treated, facial wounds generally heal well without complications. However, infection can sometimes cause delayed wound healing. We performed wound culture for the early detection of infection and to promote the healing of infected facial wounds. We included 5033 patients with facial wounds who visited the emergency room of Kangnam Sacred Heart Hospital between January 2018 and February 2021. Among them, 104 patients underwent wound culture. We analysed the pathogens isolated and the patients' age, sex, wound site, mechanism of injury, wound healing time, time from injury to culture, time to culture results, and dressing methods used. Pathogens were isolated in slightly less than half of the patients (38.46%); among them, *Staphylococcus epidermidis* was the most common (47.5%). Methicillin-resistant coagulase-negative staphylococci were isolated in six (15%) patients. Patients with complicated wounds had a longer mean wound healing time (10.83 ± 5.91 days) than those with non-complicated wounds (6.06 ± 1.68 days). Wound culture of complicated facial wounds resulted in the isolation of various types of pathogens, including antibiotic-resistant bacteria and fungi. We recommend the use of wound culture for early detection of infection to prevent delayed wound healing.

KEYWORDS

bacteria, cicatrix, facial trauma, wound healing, wound infection

Key messages

- if facial lacerations and/or abrasions are properly treated, they generally heal well without complications. However, infection can sometimes cause delayed wound healing
- if infection occurs, treatment can become difficult due to delayed wound healing. We performed wound culture for the early detection of infection and to promote healing of infected facial wounds
- through early evaluation, wound infection can be identified, and the early use of appropriate antibiotics and dressing methods can prevent delayed

wound healing. We analysed the pathogens isolated and the patients' age, sex, wound site, mechanism of injury, wound healing time, time from injury to culture, time to culture results, and dressing methods used

- pathogens were isolated in more than half of the patients (61.54%); among them, *Staphylococcus epidermidis* was the most common (47.5%)
- methicillin-resistant coagulase-negative staphylococci were isolated in six (15%) patients. Patients with complicated wounds had a longer mean wound healing time (10.83 ± 5.91 days) than those with non-complicated wounds (6.06 ± 1.68 days)
- this paper is meaningful as it is the first to analyse pathogens in facial wounds

1 | INTRODUCTION

Facial lacerations and abrasions of varying degrees are the most common conditions encountered by plastic surgeons in the emergency room.[1] The yearly incidence of facial laceration in Korea has nearly reached 120 000 since 2016, with a medical expenditure of approximately 11–12 billion South Korean Won.[2]

Most facial wounds heal well and without complications. However, infection may occur, which can delay wound healing and lead to a large amount of remnant scar tissue, resulting in poor functional and aesthetic outcomes.[1,3] To prevent this, patients with facial injuries should be appropriately evaluated and treated, especially when infection is suspected. Factors that determine wound condition include the cause of injury, time since injury, site of injury, and presence of signs of infection, and treatment should differ depending on the wound condition.[4]

Several studies have mentioned that wound culture can be performed in patients with facial wounds who show signs of infection, but no study has reported the results of wound culture in these patients.[5,6] We considered patients with complicated wounds as being at a high risk of infection and performed wound culture for early identification of infection. After confirming the presence of pathogens through wound culture, we tried to determine how this would affect wound healing and scar formation.

The purpose of this study was to analyse the pathogens isolated using wound culture from patients with facial injury and discuss the use of this method for the early detection and treatment of wound infection in these patients with the ultimate aim of achieving a reasonable and acceptable scar.

2 | MATERIALS AND METHODS

We retrospectively analysed the data of 5033 patients with facial lacerations and/or abrasions who visited the emergency room of Kangnam Sacred Heart Hospital, Hallym University between January 2018 and February 2021. Among them, 104 had undergone wound culture.

We analysed pathogens isolated and the participants' age, sex, wound site, mechanism of injury, wound healing time, time from injury to culture, time to culture results, and dressing methods used.

Lacerations of all causes except animal bites were treated with primary closure, which was performed using a two-layer technique that included buried suturing with 6–0 Vicryl and skin suturing with 6–0 Ethylon after debridement of the devitalized tissue and copious irrigation.[3] Delayed primary closure was performed 4–5 days after injury in patients with animal bites. Abrasions were treated with dressing alone. One to 2 days after receiving treatment at the emergency room, the patients visited our outpatient clinic for monitoring.[7] Wound culture was performed as follows: The head of the swab was soaked in sterile saline to allow bacteria to adhere to the swab and ensure even contact from all sides.[8] The samples were tested for the presence of gram-positive and gram-negative bacteria and fungi, and antimicrobial susceptibility tests using the disk diffusion method were simultaneously performed for gram-positive and gram-negative bacteria.[7,9] Oral, intramuscular, and/or intravenous antibiotics were used to treat wound infection. Cephalexin and netilmicin were routinely administered to provide coverage against gram-positive and gram-negative bacteria, respectively, and additional antibiotics were prescribed according to the results of antimicrobial susceptibility testing.[10] Subsequently, patients were recommended to follow up for at least 6 months for scar management and treatment.

All analyses were performed using Statistical Package for the Social Sciences (version 26.0; IBM Corporation, New York, United States). Categorical variables are expressed as frequencies and percentages. Non-normally distributed continuous variables are expressed as medians and quartile ranges. The homogeneity of the complicated wound group and the non-complicated

wound group was analysed. Comparative analyses were performed using the Mann–Whitney *U* test. Statistical significance was set at $P < .05$.

TABLE 1 Demographic characteristics of the patients (mean ± SD)

Number of patients (n)	104
Age (year)	45.51 ± 19.83
Male/Female ratio	2.47:1
Male	74
Female	30

The study protocol was approved by the Institutional Review Board (approval number: 2021–06-030). All study procedures were performed in accordance with the ethical standards of the institutional and/or national research committee and with the 1964 Helsinki declaration and its later amendments or comparable ethical standards.

3 | RESULTS

The mean age of the complicated wound group was 45.51 ± 19.83 years. There were 74 men and 30 women, with a male/female ratio of 2.47:1 (Table 1 and Figure 1).

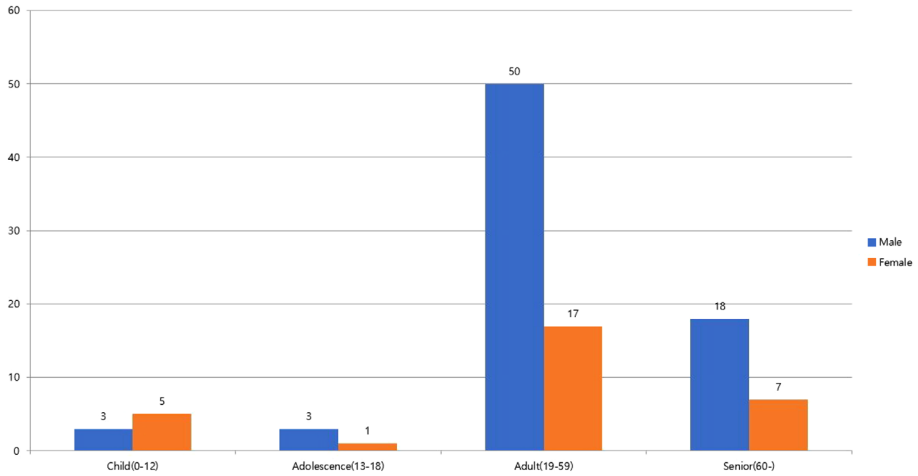

FIGURE 1 Distribution of the participants by age and sex. The mean age of the complicated wound group is 45.51 ± 19.83 years and that of the non-complicated wound group is 45.28 ± 23.01 years ($P = .940$). The participants have been classified into four groups according to their age: children (0–12 years), adolescents (13–18 years), adults (19–59 years), and older adults (≥60 years) and the corresponding distribution is 7.69% (n = 8), 3.85% (n = 4), 64.42% (n = 67), and 24.04% (n = 25), respectively. The male/female ratio is 2.47:1.

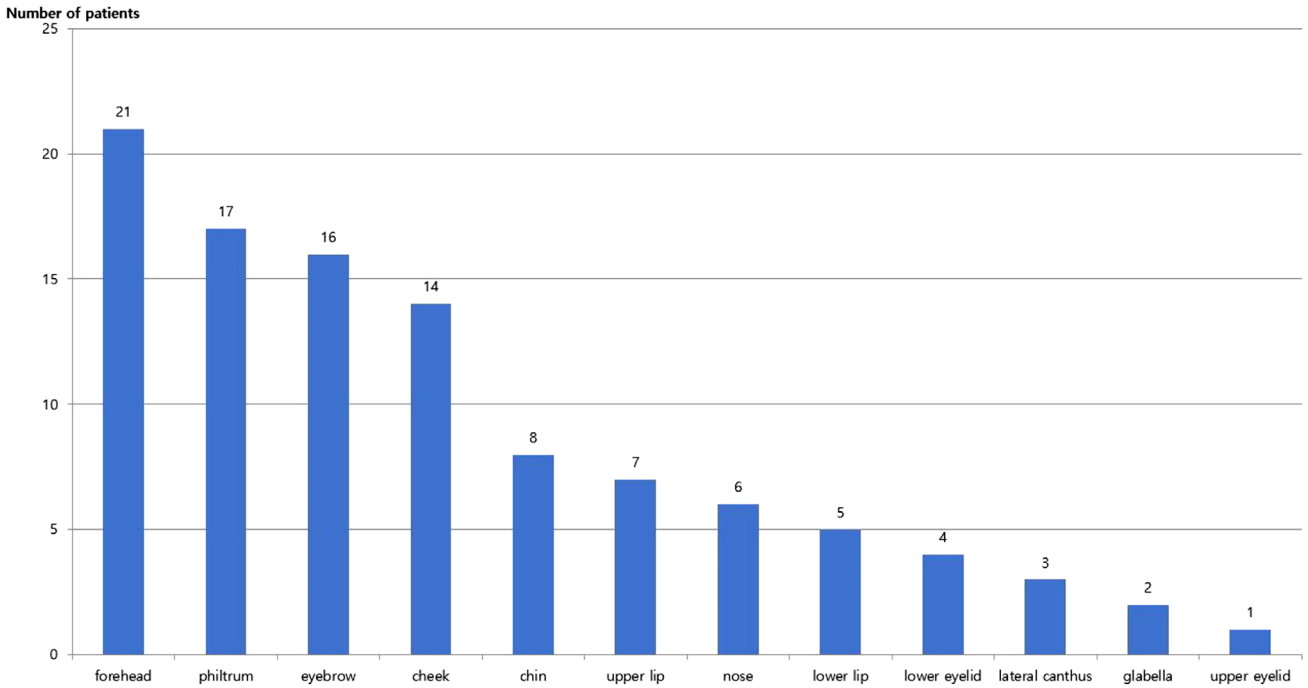

FIGURE 2 Distribution of the participants by wound site. The most common site of injury is the forehead (n = 21), followed by the philtrum (n = 17) and eyebrows (n = 16).

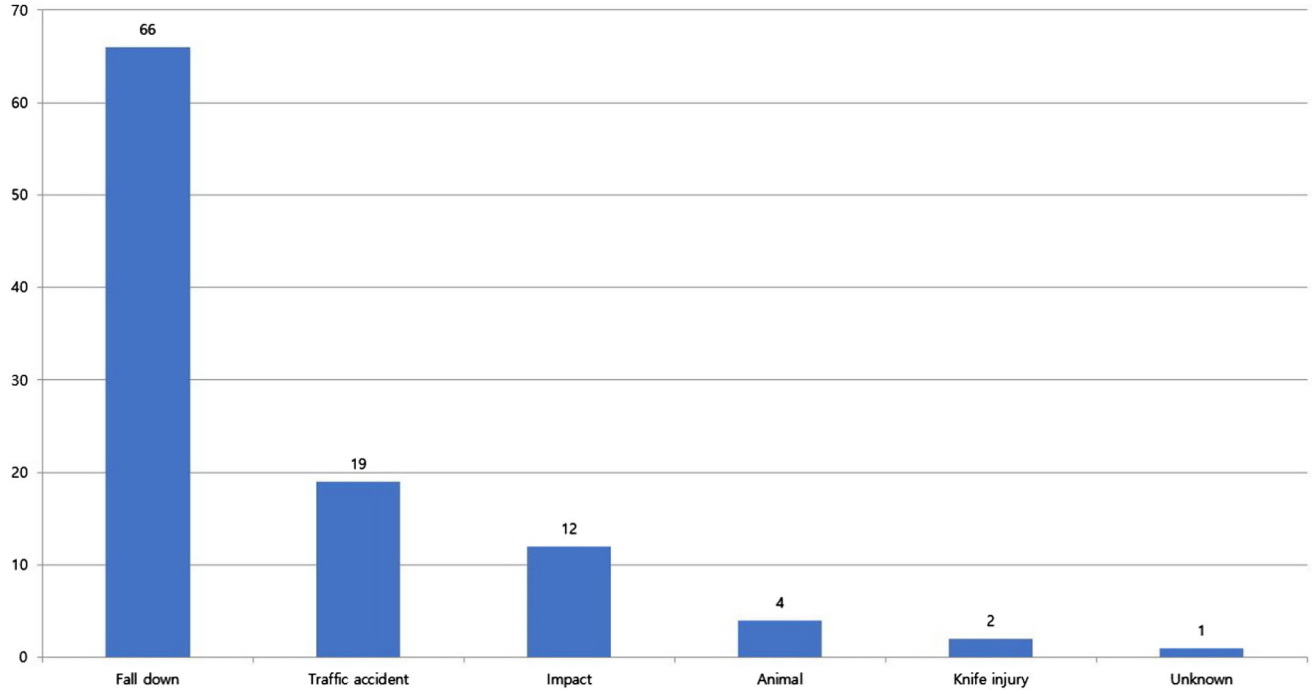

FIGURE 3 Distribution of the participants by mechanism of injury. The most common cause of injury by far was falls (n = 66), followed by traffic accident (n = 19).

TABLE 2 Factors influencing wound management (mean ± SD)

	Complicated wound group	Non-complicated wound group
Laceration length (cm)	3.74 ± 2.25	3.48 ± 2.69
Time from injury to culture (days)	1.82 ± 0.48	
Time to culture results (days)	4.43 ± 1.25	
Wound healing time (days)	10.83 ± 5.91	6.06 ± 1.68

The most common site of injury of the complicated wound group was the forehead (21 patients, 20.19%), followed by the philtrum (17 patients, 16.35%) and eyebrows (16 patients, 15.38%; Figure 2). The most common cause of injury was falls (66 patients, 63.46%), followed by traffic accidents (19 patients, 18.27%) and impact (12 patients, 11.54%; Figure 3). The mean laceration length of the complicated wound group was 3.74 ± 2.25 cm.

The mean wound healing time of the complicated wound group was 10.83 ± 5.91 days and that of the non-complicated wound group was 6.06 ± 1.68 days ($P < .05$). Wound healing time was the only variable that showed a significant difference between the two groups (Table 2).

Pathogens were not isolated on culture in over half of the patients with complicated facial wounds (64 patients, 61.54%). Among the 40 (38.46%) patients in whom pathogens were isolated, *Staphylococcus epidermidis* was the most common (19 patients, 47.5%), followed by *Klebsiella aerogenes* (4 patients, 10%) and *Streptococcus mitis/Streptococcus oralis* (4 patients, 10%; Table 3). Gram-positive bacteria, gram-negative bacteria, and fungi were isolated from 33 (82.5%), 6 (15%), and 1 (2.5%) patients, respectively (Table 4). Notably, methicillin-resistant coagulase-negative staphylococci were isolated in 6 (15%) of the patients. Wound culture was not performed in patients with non-complicated facial wounds, and it is therefore unknown whether pathogens were present in these patients' wounds.

Mepilex Lite (Molnlycke Health Care, Goteborg, Sweden) was most commonly used wound dressing before the results of the wound culture were obtained (59.62%), and Cutimed Sorbact gel (BSN Medical, Hamburg, Germany) was the most commonly used wound dressing after the culture results were obtained (81.73%; Table 5). Oral and/or intramuscular cefalexin and netilmicin were empirically administered to all patients and changed according to the results of antimicrobial susceptibility testing and wound condition.

TABLE 3 Pathogens isolated from complicated facial wounds

No growth	64 (61.5%)
Staphylococcus epidermidis	19 (18.3%)
Staphylococcus epidermidis (MS-CNS)	13 (12.5%)
Staphylococcus epidermidis (MR-CNS)	6 (5.8%)
Klebsiella aerogenes	4 (3.8%)
Streptococcus mitis/Streptococcus oralis	4 (3.8%)
Staphylococcus capitis	3 (2.9%)
Staphylococcus aureus	2 (1.9%)
Streptococcus anginosus	2 (1.9%)
Streptococcus parasanguinis	1 (0.9%)
Enterococcus faecalis	1 (0.9%)
Leuconostoc mesenteroides	1 (0.9%)
Ewingella americana	1 (0.9%)
Paenibacillus glucanolyticus	1 (0.9%)
Candida albicans	1 (0.9%)
Total	104 (100%)

Abbreviations: MR-CNS, methicillin-resistant coagulase-negative staphylococci; MS-CNS, methicillin-sensitive coagulase-negative staphylococci.

TABLE 4 Species-wise classification of pathogens (n,%)

Pathogenic bacteria	40 (100%)
Gram-positive bacteria	33 (82.5%)
Gram-negative bacteria	6 (15%)
Fungus	1 (2.5%)

TABLE 5 Wound dressings used in the emergency room and outpatient department

Emergency room		Outpatient department	
Foam dressing	62	Foam dressing	15
		Sorbact gel	46
		Ointment	1
Sorbact gel	28	Sorbact gel	28
Bactigras	11	Foam dressing	2
		Sorbact gel	9
Ointment	3	Sorbact gel	2
		Ointment	1

4 | DISCUSSION

Facial soft tissue injuries account for almost 10% of all emergency room visits in the United States.[1,4] The yearly incidence of facial lacerations in Korea has nearly reached 120 000 since 2016.[2] However, fewer than 5% of patients with facial lacerations who visit the emergency room show signs of infection.[3] Only 2.07% of the patients in this study showed signs of infection, including those in whom wound culture was not performed.

Treatment for facial lacerations and abrasions is aimed at promoting wound healing by reducing the likelihood of wound infection and minimising scar tissue.[3] Therefore, it is essential to identify the factors that determine wound condition; these include the cause of injury, time since injury, site of injury, presence of signs of infection and underlying diseases, and presence of devitalized tissues or dead space in the wound.[4,8] No study has analysed the duration of wound healing using wound culture. Therefore, we performed wound culture for the early detection of infection. Patients with non-complicated wounds, such as simple lacerations, did not undergo wound culture. We defined "complicated wound" as a wound with raw surfaces; moderate or greater than moderate amounts of serosanguinous, turbid, or purulent discharge; dirty margins; and/or multiple wound sites. Although erythema, swelling, and localised warmth also indicate wound infection, we paid particular attention to the abovementioned factors.[8]

Resident flora usually protects the host from external pathogenic invasion, but it can sometimes cause infection.[11] Therefore, despite facial wound infection being rare, it is important to identify the causative agent in patients with signs of infection. Rather than simply performing wound culture, we asked patients with complicated wounds to frequently visit the hospital, and the dressing and antibiotics used were changed according to their condition. We instructed patients to visit our outpatient department 1–2 days after suturing, and we performed wound culture at the first outpatient visit. We also replaced the dressing and assessed the wounds for erythema, localised warmth, swelling, discharge (quality and quantity), and the presence of raw surfaces at the first outpatient visit. After the first outpatient visit, they were required to visit every 1–2 days depending on the condition of the wound, and patients with diabetes, old age, poor hygiene, and uncooperative were advised to visit every day, and admission was recommended for patients with poor mobility or poor treatment compliance. In addition to the main problem, we also tried to promote the wound healing process by correcting internal problems, diabetes as the most common example, and medical problems through collaboration with internal medicine.

After wound assessment, wound culture was performed in patients with complicated wounds. Quantitative swab culture was performed, which enabled the isolation of gram-positive bacteria, gram-negative bacteria, and fungi. We simultaneously performed antibiotic

sensitivity tests for gram-positive and gram-negative bacteria using the disk diffusion method.[7,9] In recent times, the following four methods are commonly used for culture testing: qualitative culture, quantitative culture, nucleic acid amplification by polymerase chain reaction, and metagenomic analysis. Quantitative tests can also be used for all wounds. It takes several days to obtain results and specialised equipment is needed, but more accurate than qualitative tests. In addition, other tests have the disadvantage that it takes a long time for the results to come out considering the healing period of the wound.[12] Therefore, in this study, quantitative wound culture was performed, and we believe it to be a feasible and useful test for the detection of facial wound infection.

The mean wound healing time of the complicated wound group was 10.83 ± 5.91 days, and that of the non-complicated wound group was 6.06 ± 1.68 days ($P < 0.05$). "Wound healing time" is the time taken for the completion of epithelialization and cessation of discharge from the wound. The wound healing time of patients with complicated wounds was approximately 78% longer than that of patients without complicated wounds. The mean time from injury to culture was 1.82 ± 0.48 days, which is approximately equal to the time it takes for patients to visit our outpatient department after they visit the emergency room. The mean time to culture results was 4.43 ± 1.25 days. This means that, on average, culture results were obtained before wound healing had progressed to more than 50%.

The distribution of resident skin flora varies among individuals depending on age, sex, location, hygiene, and hospitalisation. In adults, the resident skin flora includes *Staphylococcus*, *Corynebacterium*, and *Acinetobacter*, with *Staphylococcus* being the most predominant among them. Coagulase-negative staphylococci are particularly important because they are the main cause of device-related infections and can lead to biofilm formation due to antibiotic resistance.[11,13] *Staphylococcus epidermidis* has been reported to be one of the most common causes of skin and soft tissue infection.[13] This report is the first to analyse the cause of infection of facial wounds. Pathogens were isolated from 40 of the 104 patients who underwent wound culture. Among the pathogens isolated, *Staphylococcus epidermidis* was the most common (19 patients, 47.5%), followed by *Klebsiella aerogenes* (4 patients, 10%) and *Streptococcus mitis/Streptococcus oralis* (4 patients, 10%). Additionally, methicillin-resistant coagulase-negative staphylococci were isolated in six (15%) patients with *Staphylococcus epidermidis* infection. Moreover, resident skin flora was isolated in over half of the patients in this study. In the absence of tissue damage, the bacteria that are a part of the resident flora have a symbiotic relationship with the host. However, in situations in which the host's immune system weakens, for example, in patients with skin lacerations, these bacteria may cause infection.[11] *Staphylococcus epidermidis* is one of the most common bacteria found in the resident skin flora.[14] Therefore, when *Staphylococcus epidermidis* was isolated, it was often regarded as a contaminant and not a true pathogen.[13] It plays an important role in preventing pathogenic colonisation of the skin by producing antimicrobial peptides.

However, *Staphylococcus epidermidis* has an antibiotic resistance gene. Methicillin-resistant coagulase-negative staphylococci can proliferate if this gene is disseminated, and since it forms a biofilm and is resistant to many antibiotics, caution should be taken to prevent the wound from becoming chronic. In this study, no patient had a chronic wound due to methicillin-resistant coagulase-negative staphylococci, but if biofilm formation occurs, additional debridement or changes to the antibiotics administered are required to remove it.[13] Therefore, early detection of infection of complicated wounds is important, wound culture should be performed as early as possible, and the dressing and antibiotics used should be changed according to the culture results and clinical features of the wound.

Several studies have stated that the routine use of antibiotics is not essential in patients with facial lacerations and abrasions because of low infection rates (less than 5%)[3,5,14] However, we recommend the use of oral and/or systemic antibiotics in patients with complicated wounds, because these wounds are likely to be infected.[3] Cephalexin and netilmicin were used for coverage against gram-positive and gram-negative bacteria, respectively, and additional antibiotics were administered according to the results of antimicrobial susceptibility testing.[10] It is also important to control other factors that can cause infection through adequate debridement of devitalized tissues, copious irrigation, and accurate suturing of wounds.[3]

The choice of dressing for complicated wounds is also important; therefore, we analysed the dressing used before and after the culture results were obtained.[8] Dressing materials are largely divided into traditional and modern. Gauze is the most commonly used, relatively inexpensive, and easy to use traditional dressing material. However, traditional dressings require frequent replacement because they cannot absorb large amounts of discharge. In addition, because they do not provide a wet environment, they are unsuitable for use in patients with dirty exudative wounds. Modern dressings have been developed to compensate for these shortcomings. In addition to covering wounds, they help in wound healing by creating a wet environment.[14,15] The dressing used most commonly in this study before culture results were

obtained was foam dressing using Mepilex Lite (59.62%), followed by Cutimed Sorbact gel dressing (26.92%) and Bactigras (Smith and Nephew, Romford, Essex, UK; 10.58%). Cutimed Sorbact gel dressing was the most commonly used dressing after culture results were obtained (81.73%), followed by foam dressing (16.35%). Cutimed Sorbact gel dressing has a coating of a hydrophobic fatty acid (dialkyl carbamoyl chloride [DACC]) instead of active antibiotic agents.[16] Most of the microbes in the wound are hydrophobic, as is DACC; these two substances are irreversibly bound through hydrophobic interactions.[17] The rationale behind our use of Cutimed Sorbact gel dressing in this study is related to differences in mechanisms of action between various types of dressing.

5 | CONCLUSION

The pathogens isolated from complicated facial wounds in this study were more diverse than expected, and antibiotic-resistant bacteria was also isolated. Pathogens were isolated in 39.5% of patients with complicated facial wounds, as many as 15% of which were super-bacteria. In addition, in patients in whom pathogens were isolated, the wound healing time was about approximately 80% longer than in those in whom pathogens were not isolated. If infection occurs, treatment can become difficult due to delayed wound healing. Therefore, if a facial wound meets the criteria for complicated wounds, early evaluation for infection is needed. We recommend the use of early wound culture for the detection of infection. Through early evaluation, wound infection can be identified, and the early use of appropriate antibiotics and dressing methods can prevent delayed wound healing. This paper is meaningful as it is the first to analyse pathogens in facial wounds. However, it has a limitation in that it was not possible to perform a wound culture of non-complicated wounds. If this can be investigated in future studies, further evaluation and analysis of pathogens in facial wounds will be possible, which will further the understanding of this topic and help in preventing infection and promoting wound healing.

FUNDING INFORMATION

The authors have no financial interests to declare in relation to the content of this article.

CONFLICT OF INTEREST

The authors declare no conflicts of interest.

DATA AVAILABILITY STATEMENT

The data that support the findings of this study are available on request from the corresponding author. The data are not publicly available due to privacy or ethical restrictions.

REFERENCES

1. Kretlow JD, McKnight AJ, Izaddoost SA. Facial soft tissue trauma. *Semin Plast Surg*. 2010;24:348-356.
2. Health Insurance Review & Assessment Service. Available at: http://opendata.hira.or.kr/op/opc/olap4thDsInfo.do. Accessed August 8, 2021.
3. Hollander JE, Singer AJ. Laceration management. *Ann Emerg Med*. 1999;34:356-367.
4. Lee RH, Gamble WB, Robertson B, Manson PN. The MCFONTZL classification system for soft-tissue injuries to the face. *Plast Reconstr Surg*. 1999;103:1150-1157.
5. Otterness K, Singer AJ. Updates in emergency department laceration management. *Clin Exp Emerg Med*. 2019;6:97-105.
6. Lee JH, Jeon MS, Lee DL, Shin HK, Jung HS. Analysis of patients with facial lacerations repaired in the emergency room of a provincial hospital. *Arch Plast Surg*. 2015;42(1):34-39.
7. Levine NS, Lindberg RB, Mason AD Jr, Pruitt BA Jr. The quantitative swab culture and smear: A quick, simple method for determining the number of viable aerobic bacteria on open wounds. *J Trauma*. 1976;16:89-94.
8. Healy B, Freedman A. ABC of wound healing: infections. *BMJ*. 2006;332:838-841.
9. Coorevits L, Boelens J, Claeys G. Direct susceptibility testing by disk diffusion on clinical samples: A rapid and accurate tool for antibiotic stewardship. *Eur J Clin Microbiol Infect Dis*. 2015;34:1207-1212.
10. Kwak YG, Choi SH, Kim T, et al. Clinical guidelines for the antibiotic treatment for community-acquired skin and soft tissue infection. *Infect Chemother*. 2017;49:301-325.
11. Cogen AL, Nizet V, Gallo RL. Skin microbiota: A source of disease or defence? *Br J Dermatol*. 2008;158:442-455.
12. Martin JM, Zenilman JM, Lazarus GS. Molecular microbiology: new dimensions for cutaneous biology and wound healing. *J Invest Dermatol*. 2010;130:38-48.
13. Percival SL, Emanuel C, Cutting KF, Williams DW. Microbiology of the skin and the role of biofilms in infection. *Int Wound J*. 2012;9:14-32.
14. Medel N, Panchal N, Ellis E. Postoperative care of the facial laceration. *Craniomaxillofac Trauma Reconstr*. 2010;3:189-200.
15. Dhivya S, Padma VV, Santhini E. Wound dressings - A review. *Biomedicine*. 2015;5:22.
16. Probst A, Norris R, Cutting KF. Cutimed Sorbact made easy. *Wounds Int*. 2012;3(2).
17. Ljungh A, Wadström T. Growth conditions influence expression of cell surface hydrophobicity of staphylococci and other wound infection pathogens. *Microbiol Immunol*. 1995;39:753-757.

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